GENERAL NOTES.

WILLIAM HARKNESS.— For the following account of the late Professor HARKNESS we are indebted to one of his life-long friends and colleagues:—

WILLIAM, son of JAMES and JANE (WEILD) HARKNESS, was born at Ecclefechan, Scotland, December 17, 1837. His parents were natives of Scotland, and came to New York in May, 1839. The father was a Presbyterian clergyman and also a physician of the homeopathic school.

During his boyhood WILLIAM lived in New York City and in Fishkill, N. Y., and attended the Chelsea Collegiate Institute in New York, and private schools in Fishkill Landing and Newburgh, N. Y. He entered Lafayette College in 1854, but, owing to the removal of his parents to Rochester, N. Y., he became a student in Rochester University in 1856, graduating there with the degree of A. B. in 1858. From Rochester he received the degree of A. M. in 1861, and that of LL.D. in 1874. From Lafayette he received the honorary degree of A. M. in 1865. He was a reporter in the New York Legislature in 1858 for the *Albany Atlas and Argus;* and in the Pennsylvania Senate, in 1860, for the *Harrisburg Daily Telegraph.* The skill acquired in this work as a stenographer was of great service to him throughout his active life. He studied medicine and graduated from the New York Homeopathic Medical College, receiving the degree of M. D. in 1862.

On August 1, 1862, he was appointed an "aid" at the United States Naval Observatory. After the second battle of Bull Run, August 30, 1862, he volunteered as a medical man to assist in the relief of the wounded.

On August 24, 1863, he was appointed a Professor of Mathematics in the United States Navy, with the relative rank of Lieutenant-Commander, to fill a vacancy caused by the death of Prof. JOSEPH HUBBARD. During EARLY'S attack on Washington, July 11-12, 1864, he served as a volunteer surgeon.

From October 17, 1865, to June 28, 1866, he was attached to the United States monitor *Monadnock* for the purpose of ob-

serving the behavior of her compasses under the influence of the heavy iron armor of the vessel. During this period the *Monadnock* made the trip from Philadelphia around Cape Horn to San Francisco, and Professor HARKNESS made observations to determine the terrestrial magnetic declination, inclination, and horizontal force at the principal posts on the route. The observations and the discussion of the results were published by the Smithsonian Institution in 1871, a quarto volume of 225 pages, under the title, "Observations on Terrestrial Magnetism and on the Deviation of the Compasses of the United States iron-clad *Monadnock* during her cruise from Philadelphia to San Francisco in 1865 and 1866, by WILLIAM HARKNESS, M. D."

On returning to Washington he was attached to the Hydrographic Office from October 14, 1866, to October 1, 1867, and to the Naval Observatory from October 1, 1867, to May 30, 1874.

On August 7, 1869, he observed the total solar eclipse at Des Moines, Iowa, and at that time discovered the now well-known Coronal line K 1474.

On December 22, 1870, he observed the total solar eclipse at Syracuse, Sicily, and early in 1871 visited several of the principal observatories in Europe.

On November 13, 1871, he was appointed one of the original members of the Transit of *Venus* Commission, and was principally employed with other members of the Commission in arranging for the observations of the transits of December 9, 1874, and of December 6, 1882. From November, 1871, to the time of his detachment from the Observatory in 1874, he did but little observing but devoted most of his time to work of the Transit of *Venus* Commission. Professor HARKNESS was formally detached from the Observatory on May 29, 1874, and did not resume his connection with astronomical work at the Observatory for twenty years.

He was in charge of the Transit of *Venus* party at Hobart, Tasmania, where the weather on December 9, 1874, was favorable for good observations. On June 22, 1875, he was ordered to the Observatory for service with the Transit of *Venus* Commission in connection with the reduction of the observations by the different observing parties.

For the purpose of utilizing the photographs taken by these parties Professor HARKNESS devised a measuring engine for determining with sufficient accuracy the relative positions, on the plate, of the centers of the Sun and *Venus*. About this time he designed an attachment to a spherometer caliper for measuring the figure of pivots of astronomical instruments.

He observed the Transit of *Mercury* on May 6, 1878, at Austin, Texas; and the total solar eclipse of July 29, 1878, at Creston, Wyoming. He also edited the volume containing the reports of the observations of the 1878 eclipse. In 1880 and 1881 the photographic observations of the Transit of *Mercury* were reduced under his supervision.

About this time he was engaged with others in making experiments to determine the best form of apparatus for photographing the solar corona during total eclipses.

In 1881-83 he did some work on the reduction of GILLISS's Zones, observed at Santiago, Chile, in 1849-52.

For some time previous to 1882 he was employed, under the direction of the Transit of *Venus* Commission, in making preparations for observing the transit of *Venus* on December 6th of that year. He observed the transit of *Venus* from the grounds of the Naval Observatory in Washington and was afterwards assigned to the duty of reducing all the observations made by the parties organized under the Transit of *Venus* Commission. In about six years the result from the photographic observations was reached and a brief statement was published in a report to the Secretary of the Navy.

From 1888 to 1891 he was principally occupied with his work on "The Solar Parallax and its Related Constants," which was printed in 1891. From 1891 to 1894 he was engaged in miscellaneous work, some of it relating to the building of the new Naval Observatory and the construction of some of the new instruments.

On October 21, 1892, he was appointed chief astronomical assistant to the Superintendent of the Naval Observatory and on September 21, 1894, he was appointed Astronomical Director of the Observatory with general supervision of all the astronomical work. On June 30, 1897, he was appointed Director of the American Ephemeries and Nautical Almanac, and he retained both these offices until his retirement for age, December 17, 1899, with the rank of Rear-Admiral.

Professor HARKNESS published many scientific papers and was a member of a number of scientific societies.

He was a founder and at one time President of the Cosmos Club in Washington, a President of the Philosophical Society of Washington, Vice-President of the American Association for the Advancement of Science in 1881 and 1885, and President of the same society in 1893.

His principal public addresses were:—

Vice-Presidential address before Section A, American Association for the Advancement of Science, on "Transits of *Venus*";

Presidential address in 1887 before the Philosophical Society of Washington, on "The Progress of Science as Exemplified in the Art of Weighing and Measuring";

Presidential address in 1894 before the American Association for the Advancement of Science, on "The Magnitude of the Solar System."

During Professor HARKNESS'S service at the Naval Observatory, from 1862 to 1874, he worked as an observer with the Prime Vertical Transit, the Mural Circle and the Transit Circle. He had charge of the latter instrument from January 1, 1870, to May 29, 1874. As an observer, he was methodical, painstaking, and especially careful in regard to the most minute details. A duly formulated regulation always received his profound respect.

Soon after 1871 his health seemed to demand special care, and from that time until his detachment in 1894 he did very little observing.

His principal work from 1874 to 1894 was with the Transit of *Venus* Commission and after the transit of 1882 he had charge of all the reductions. The general government spent large sums of money in fitting out the various observing parties in 1874 and 1882 and many thousands of dollars in measuring the photographic plates and in making the necessary reductions. Much interest was felt among astronomers in regard to the deduced value of the solar parallax and the Commission authorized and urged a speedy reduction of the work. In 1889 a brief report, announcing the value of the solar parallax as found from the measures of the photographic plates, was printed but no further progress has been made. The value of the parallax from the telescopic observations of the four con-

tacts has not been computed nor have the reports of the observers been printed.

For many years much dissatisfaction had existed among the astronomers of the country with the management of the Naval Observatory, the only government institution of its kind. Many efforts had been made to secure a competent astronomer for superintendent but without success.

Soon after the observatory was moved to Georgetown Heights the pressure from astronomers outside of Washington became so great that it was deemed politic to make an apparent concession to the demand, and the position of Astronomical Director was created by order of the Secretary of the Navy. By the terms of that order the entire astronomical work of the observatory was placed under the supervision of the Director, but he had no adequate control of the personnel. In reality the order bestowed the maximum of responsibility and the minimum of power.

The selection of the proper person for Director was not an easy task. To many of the available officers it was a very undesirable berth. Finally it was accepted by Professor HARKNESS, against the advice of friends, and he assumed the duties with the firm belief that the complete success of the new departure was assured.

To that end he labored with great zeal, devoting his whole time and strength to the cause.

The magnitude of the undertaking and its probable failure were soon apparent, but to the day of his retirement he worked and hoped for ultimate success.

After he left the Observatory the office was continued but a little more than a year.

The work of Astronomical Director and as Director of the Nautical Almanac had already begun to affect seriously his constitution and when, in January, 1900, he attempted to take up again some portions of the unfinished Transit of *Venus* work he was unable to recognize the meaning of the formulæ with which he had been so familiar but five years before. Attributing this failure to nervous prostration he went to his home in Jersey City where he hoped that a few weeks of rest would completely restore his health. There his condition changed but little until February, 1903.

Occasionally some slight improvement would occur but it would be of short duration, and he was unable to do any mental work beyond writing a short letter.

On February 18th it was manifest that Bright's disease had developed. Its progress was rapid; and, happily forgetting his worries and struggles, he passed on peacefully on the afternoon of February 28, 1903.

Spiral Nebulæ.—Sir ROBERT BALL in his lectures on "Astronomical Problems," in London recently, drew attention to the spiral form of many of the great nebulæ. Professor KEELER, he remarked, had during his lifetime attempted to make a chart of the sky by means of photographs taken with the great Crossley reflector at the Lick Observatory. For this purpose he divided the sky into sections, and had intended to photograph each in turn. This task he did not accomplish; but whereas before his investigation began the number of known nebulæ was about 8,000, his investigation left this number multiplied to at least 120,000. Now, there were nebulæ and nebulæ; they differed as one star differs from another in glory; their variety was infinite. They might be divided into young nebulæ and adult nebulæ. Professor KEELER found that half the nebulæ of the sky were spiral nebulæ, and presented us with the astonishing fact that next to a fixed star the spiral nebula was the most characteristic object of the sky. The spiral nebula was to be regarded as an adult nebula, because Sir WILLIAM HUGGINS's beautiful spectroscopic method revealed to us that its spectrum was a continuous spectrum, and that therefore the nebula was no longer a mere chaos of incandescent gas, but had begun to condense down into something more approaching substance. The evolution of the chaos of gas into a spiral proceeded solely from the mutual action of its parts.

ANDREW GREIG.

Source of the Sun's Heat.—In another lecture Sir ROBERT BALL considered the sources of the heat of the Sun. He reviewed the theory of HELMHOLTZ. According to this theory, the Sun is shrinking. It shrinks sixteen inches in diameter daily; it has been shrinking daily ever since it was a great gase-

ous nebula, extending over a millionfold greater extent of space. Now, the molecules of a body—we may, for clearness, think of a gaseous body and of the molecules of a gas—are in constant vibration while the body is radiating heat. If heat is added to the body, the rapidity of the motion of the molecules increases. Conversely, if the rapidity of the movement of the molecules increases, more heat is given out. The falling in of the Sun's circumference due to the sixteen inches of daily shrinking gives these molecules some distance to fall. It is not a great distance, but there are a great many molecules. Their motion is increased by their daily drop of sixteen inches. Consequently, this addition to their velocity adds to their heat, and thus by the Sun's shrinking the supply of radiated heat is lifted towards the level of the expenditure. But the lecturer proceeded to show that this is not a complete or a completely satisfactory explanation. We may take it that in shrinking from its nebulous form down to its present dimensions the Sun has given out heat equivalent to about 3,400 times its own mass in coal. Each coal unit would have lasted the Sun 2,800 years. If we continue this calculation, and seek to find the number of coal units that the Sun will have consumed between the time it was a gaseous nebula and the time when it shall become a solid body as dense as the densest substance known,—platinum,—we find that it will have consumed 8,300 coal units. In other words, roughly speaking, 24,000,000 years will have elapsed. But 24,000,000 years between the Sun's gaseous nebulous state and the state in which it will become at least as cold as the Earth is now, and cease practically to give out heat at all, is not enough. We know by various considerations that this estimate is too small, and therefore there must be other possible sources of the Sun's heat. What other sources were there? The fall of meteors into the Sun had been suggested; but it was shown by a simple calculation that the quantity of meteors, traveling at 400 miles a second, which would have to fall into the Sun each day to keep up its heat would have to be equivalent in mass to the Moon.

Finally, Professor BALL considered another point. The Earth received heat from the Sun, but the Sun was radiating heat everywhere. If a spectator on the Sun compared the space in the heavens occupied by the Earth with that occupied

by the Great Nebula in *Orion,* he would find that the Earth occupied only one two-hundred-thousandth part as much space as the *Orion* nebula. Therefore, we had this fact, that the Great Nebula in *Orion,* though it was a million times farther from the Sun than we were, was receiving 200,000 times as much heat a day. Now, there were visible to our telescopes perhaps about 120,000 nebulæ—all giving out heat, as the Sun had been for ages giving out heat, and all of them sending out heat in all directions. If the nebulæ of the sky had all received heat from the Sun, then—and here was the point—the solar nebula had received heat from the stars in its turn.

ANDREW GREIG.

The Age of the Sun.—Sir ROBERT BALL in his concluding lecture at the Royal Institution, London, dealt with the problem of the age of the Sun, if it were assumed that the Sun and its planets had been evolved from a nebula. He showed the mathematical reasoning by which it is proved that no ray of the Sun can ever escape to infinity. If we supposed the universe to be split up into cubes with sides a billion miles long, a billion miles being the distance of the nearest fixed star, and if at the corner of each of these cubes were placed something no larger than a molecule, no larger even than an "electron," then all the rays of the Sun would be stopped within a finite distance. It would require the universe to be peopled with matter no more thickly than an electron to a billion cubic miles to capture every ray. Now, let the Great Nebula in *Orion* be considered. That nebula caught and stopped one ten-thousandth part of the rays of the Sun; and if the stars above the tenth magnitude be reckoned at 600,000, then *Orion* might be regarded as stopping the whole light of sixty stars during the whole of its life as a nebula. The energy thus received would immensely add to its own energy. Similarly, the rays of energy which the Sun, once a nebula perhaps not much less in size than the great Dumb-bell Nebula, had received must have greatly prolonged its life as a nebula. The 24,000,000 years which were all that could be allowed it, had it received no energy from outside, must have been increased to a higher order of number altogether. Professor BALL did not hesitate to write the figure as a hundred million years, and that, he hinted, he regarded as much too small for the age of the Sun. ANDREW GREIG.

The South Polar Cap of Mars.—In the May number of the *Astrophysical Journal,* Professor E. E. BARNARD gives some account of his observations of the South Polar Cap of *Mars,* made at the Lick Observatory during the oppositions of 1892 and 1894. In addition to the usual drawings of the planet, Professor BARNARD made careful micrometer measures of the diameter of the Polar Cap throughout both oppositions,—a practice that is heartily to be commended in the study of all planetary markings. Recently Professor BARNARD reduced these measures to the mean distance of *Mars,* and then drew curves, using the measured diameters of the Polar Cap as ordinates, and the days before or after the summer solstice for the southern hemisphere of *Mars* as abscissas. Two facts of great interest are at once evident from these two curves: (1) they are parallel throughout, showing that the cap at both oppositions followed with surprising closeness the same law of decrease; and (2) the cap continues to decrease for a month or more after the summer solstice, indicating that on *Mars,* as on the Earth, the time of highest temperature is not reached until several months after the maximum of solar heat.

Professor BARNARD seems to incline to the early view that the Polar Caps on *Mars* are due to accumulations of snow, saying that this is as good a theory as any of those put forward to-day to explain the phenomenon.

At the last annual general meeting of the Royal Astronomical Society the society's gold medal was awarded to Professor HERMANN STRUVE, Director of the Königsberg Observatory, for his work on the satellites of *Saturn.*

Dr. FRANK SCHLESINGER resigned his position as observer in charge of the International Latitude Station at Ukiah, Cal., on May 1st, 1903, to accept a position at the Yerkes Observatory. Dr. S. D. TOWNLEY is Dr. SCHLESINGER's successor at Ukiah.